Managing the Continuous Improvement Loop of Educational Systems: Students as key actors in program evaluation

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MANAGING THE CONTINUOUS IMPROVEMENT LOOP OF EDUCATIONAL SYSTEMS: STUDENTS AS KEY ACTORS IN PROGRAM EVALUATION

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ABSTRACT

More and more, educational frameworks and accreditation bodies recommend implementing a system to evaluate and improve the quality of higher education institutions. This paper describes a student self-evaluation of a French engineering school which was carried out with an external institution as client. It describes the methodology and standards adopted by the students in order to conduct the evaluation, interview stakeholders, and rate compliance with maturity levels. An analysis of the quantitative and qualitative results of this evaluation is drawn, both from the quality assurance and student perspectives. The benefits, bias, and difficulties of this student-led institution evaluation are discussed. Finally, in this paper, the authors identify the skills specific to quality assurance engineers which this project allowed students to develop. They conclude on possible future issues concerning evaluation, such as student-led cross-evaluations among institutions. This paper will permit readers (i) to identify the strengths and weaknesses of a student-led evaluation, (ii) to validate or not the opportunity of dedicated student projects within their programs to facilitate the continuous improvement loop, and (iii) to underline specific student skills developed in such projects.

KEYWORDS

Engineering education, program evaluation, quality assurance, self-evaluation, students as key actors in change process.

INTRODUCTION

An educational continuous improvement or reform is a tricky strategic and engineering issue [1]. Evaluations have a determining effect on the institutional policies of higher education institutions (HEI) and these institutions are required more and more to meet quality standards [2]. As such, program monitoring and transformation play a recurrent and key role in the future of an institution.

Several models of quality management in education have appeared based on corporate styles as found in the industry (e.g. Malcom Baldrige Performance Excellence Program [3], European Foundation for Quality Management Excellence Model [4]). Requirements defined by accreditation bodies (e.g. ABET, Engineers Australia, CEAB, CTI) tend to integrate processes for better quality management in their standards. Several evaluation models and processes could cohabit with those of accreditation bodies (external evaluation with a clear focus on accountability - moving slightly towards continuous improvement recently) [2]. As an example, the Conceive-Design-Implement-Operate (CDIO) framework [5] proposes twelve standards with a clear focus on internal evaluation using maturity levels (from 0 to 5). Standard #12, Program Evaluation, is the CDIO cornerstone for continuous improvement. For example, at the maximum level 5, standards 2, 3, 6, 8, and 11 should include evaluation by external groups (e.g. alumni, industrial partners' stakeholders).

Self-evaluation, most often only conducted internally by deans or program leaders, is not so objective. It is hard for an institution to identify its own weaknesses due to a lack of detachment. Interviews of various stakeholders (e.g. students, alumni) involved in an educational system provide a more objective view. As proposed in the SPEAQ project [6], students are very good stakeholders in the quality process to respond to questions relating to their learning experience, their understanding of the concept of quality in higher education and their influence (voice) in views on the quality process. Why not involve students directly, as quality managers, in the self-evaluation process? What are the benefits of students as key actors in the change process?

In order to be continuously prepared for accreditations, and more easily deal with resistance to the changes induced by reforms, Telecom Bretagne, a French graduate engineering school, has chosen to rely on the CDIO standards [1]. Following this approach of engaging students in the process, a student activity was proposed at Telecom Bretagne in 2012. Its main objective was to carry out a student-led self-evaluation of the institution. The context is a semester project for an international student team, in a CDIO collaborator school, with an external CDIO institution (Turku University of Applied Sciences) as client of this project (each student project must have an external client responsible for requirements definition and validation). The use of students as self-evaluators was not unique, since in an earlier quality assurance HEI project, student participation in program self-evaluation had already been used with good results [7]. Other ways to engage students in continuous improvement and quality assurance processes have also been used [8]. However, the proposed activity at Telecom Bretagne was different, essentially in terms of how central a role the students had in the self-evaluation process.

This paper is structured as follows: First, the methodology adopted by the students to conduct the evaluation is described, including interviews of stakeholders, and rating of compliance with CDIO standards. Then, an analysis of the quantitative and qualitative results of the evaluation is drawn. The benefits, bias, and difficulties of this student perspective are discussed. Finally, the authors identify the skills specific to quality assurance engineers, e.g. qualitative analysis, analysis with uncertainty (i.e. CDIO 2.1.3 and 2.1.4), and auditor communication skills (i.e.

3.2.7), which this project allowed students to develop. They conclude on possible future experiments concerning evaluation, such as cross-evaluations among partner institutions to be conducted by students.

CONTEXT: A SEMESTER PROJECT FOR QUALITY ASSURANCE (QA) BY STUDENTS

Since 2003, Telecom Bretagne's generalist engineering program has relied on a pedagogical integrated framework including four semester projects (approx. 120 hours per student per semester) [9]. The whole project framework conforms to the "V" life cycle model of an industrial project. Each semester project focuses on specific phases and the intended learning outcomes are defined and gradually assessed through the semesters. The fourth semester "S4-Engineering project" covers most phases of a project life cycle, from reformulating the client's requirements, to supplying the final product (e.g. system, service or process) and validating it. The project (different for each student group, team of 5 to 6) is to be proposed by an external partner (industrialist, association, local community, etc.) and monitored by at least two faculty members from two different disciplines. A third faculty member coordinates regular progress and the student project management beyond the scientific and technical considerations.

Relying on project-based learning principles, this activity balances theoretical and practical activities. It leaves a great deal of autonomy to students and is resolutely open to the client. Overall, this S4 project comprises approximately 600 hours of student activities, led by an international team (50% of students at Telecom Bretagne are non French native). After a short kick-off to shed light on learning outcomes [10], followed by mandatory initial interactions with their client for requirement engineering, the student team delivers and presents a project management plan at the end of the first month. At the end of the project the team has to deliver a final technical report, a project summary, to the client as well as produce a (triptych-style) promotion leaflet and poster which are available on their stand for the final forum in the institution hall, before the final defence in front of a jury including the client.

The main S4 learning outcomes (cf. CDIO syllabus) under focus for all the S4 projects are as follows: 2.1 Engineering Reasoning and Problem Solving, 2.4.7 Time and Resource Management, 3.1 Teamwork, 3.2 Communications, 4.3.4 Development Project Management, and 4.5 Implementing.

METHODOLOGY: FROM CDIO UNDERSTANDING TO THE STUDENT ANALYSIS

For the specific S4 project addressed in this paper, students decided to perform their evaluation in 3 stages: (i) understanding of their institution's educational framework, of the CDIO standards, and planning of interviews; (ii) development of an interview guide and carrying out the interviews; and (iii) analysis of collected data, standards rating and improvement propositions.

Stage 1: Understanding of Educational Frameworks and Planning

Due to their lack of knowledge of CDIO standards, students began the project by a study stage to understand the CDIO approach, the twelve standards and the way of rating these standards, with the invaluable help of the external partner (by videoconferencing). The external partner proposed the use of the CDIO Standards v 2.0 (with customized rubrics) [11]. In addition, students were provided with two QA in HEI–project deliverables [12, 13] ("Guidelines to self-

evaluation" and self-evaluation report of the Information Technology program) from Turku University of Applied Sciences.

The second step was then to obtain a complete view of the institution to be evaluated, with the roles and responsibilities of the main actors. At the same time, students had to establish a correlation between the Telecom Bretagne structure, hierarchy, and program and the CDIO concepts.

The next step was to identify and select the most relevant stakeholders to interview. With the help of Telecom Bretagne dean of education, critical stakeholders (e.g. program managers from different domain-specific departments) were listed and associated with CDIO standards. The objective was to cover at least each standard with two interviews and to optimize the number of interviews to be conducted. The critical potential stakeholders (approx. 50 persons and groups) were then listed and linked to each standard to which they were related, optimizing time by asking the right people the right questions.

Stage 2: Development of an Interview Guide and Conducting Interviews

Students developed an interview guide. This guide contains thirteen parts, a general section and one section for each standard. The questions were written in order to facilitate the gathering of evidence for each CDIO standard rating. The book "Rethinking Engineering Education" [5] was extensively used by the students as guidance in order to make the questions more targeted, professional, and clearer. In addition, the self-evaluation guidelines [7, 12, 13] and CDIO standards version 2.0 [11] provided help in formulating the questions. The first approach considered by the student team was to send the questionnaire by email and to wait for the answers. However, as several interviewees did not thoroughly understand the CDIO standards details, further explanations were needed so as to give adequate answers. The team finally decided to conduct face to face interviews.

The different steps of each interview were:

1. Project and CDIO introduction (student team)
2. General questions
3. And, for each standard:
    a. specific introduction
    b. standard related questions
    c. improvement propositions related to the standard

Stage 3: Analysis of Collected Data, Standards Rating, and Propositions for Improvement

Once all the interviews completed, the gathered information was analyzed in order to rate each CDIO Standard using the 0 to 5 maturity scale. To this end, the CDIO Standard rubrics were studied meticulously after the interviews at each level. Since they rely on a layering style (i.e. each maturity level evidence criteria is a requirement for the next), the sentences were systematically converted into preconditions necessary to move up the scale. Based on this strategy and justified by the collected evidence, each standard was assessed and rated by the students. At the end of this phase, several improvement propositions were made by the student team.

Quantitative & Qualitative Elements

The total time spent by the student team on this evaluation work package amounted to 220 hours: 50 hours for stage 1, 120 hours for stage 2, and 50 hours for stage 3. Other work packages addressed project management, evaluation model alignment with ISO SPICE standards [14] and SEI-CMMI, dissemination & communication, etc. Within the evaluation work package, the average duration of an interview task was two hours, each interview being conducted by two interviewers. Due to schedule constraints over the semester, only ten interviews were carried out. The choice of interviewees covered Education and Human Resources Management as well as several program leaders (e.g. Projects or Computer Science domains). Alumni and industrial partners or recruiters were not considered, nor students other than the student team (which gave a subjective viewpoint).

Each interviewee answered a minimum of four standards and each standard was questioned at least twice. Feedback for continuous improvement and development was systematically given by the interviewees at the end of the interview. At the end of the evaluation, five improvement propositions were made by the students, for example:

- Create a formal position in the organization for a person in charge of quality assurance and regular evaluations;
- Develop systematic feedback and comments to students from past assessments;
- Homogenize the lecture notes through the various domains;
- Create a student building used for personal and team work, question students about their workspace needs and ensure powerful wireless access in all workspaces.

At the end of the project, the feedback from the external partner on the reports produced by the students and the whole project was very positive and motivating for them (cf. self-efficacy). However, two remarks were made: in view of the objectives and constraints of the project, (i) the amount of work done by the students seemed too time consuming, and (ii), they should have given feedback on the evaluation to all the interviewees at the end of the project.

CONCEPTUALISATION: EVALUATION TRIANGLE ECOSYSTEMS

Several processes of evaluation could be conceptualized depending on stakeholders. For internal evaluations, more focused on continuous improvement than accountability, from an institutional viewpoint, academic deans (D) or rectors (R) are the main decision-makers. Several other stakeholders are part of the quality system, e.g. students (S), faculty members (F), alumni (A), industrial partners (I), program leaders (PL).

A classical process of self-evaluation consists of each stakeholder, individually, bringing information hierarchically up to the dean (cf. Figure 1-a), the rector being able to align the elements with the strategy, mission, resources, etc. Another process, more collaborative in layers, could involve group sessions of similar stakeholders, reflectively analysing and evaluating some standards, before bringing results and findings to program leaders or deans (cf. Figure 1-b). Less hierarchical group sessions involving mixed stakeholders could be chosen as another process. Each process has its strengths and weaknesses.

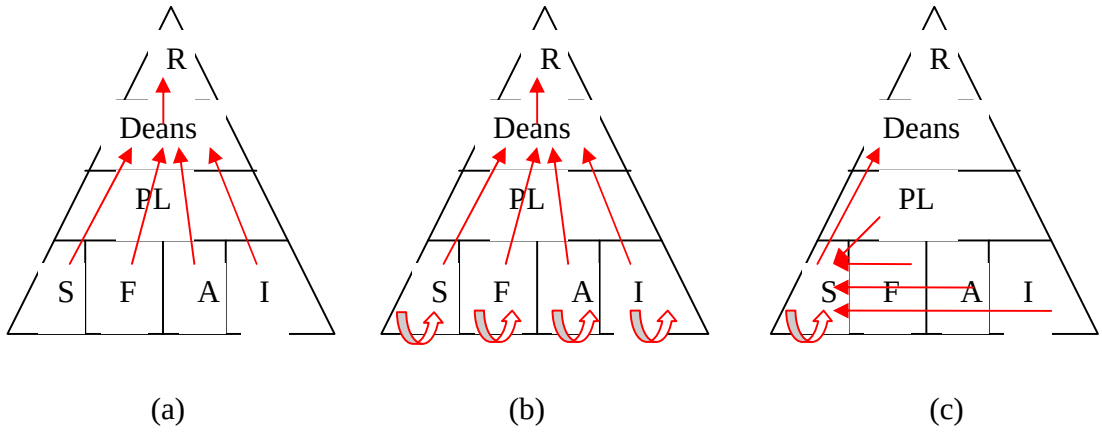

Figure 1. Potential self-evaluation processes within an HEI

The process followed in this student project conforms more to that of Figure 1-c. Evaluations were separated into categories (standards # stakeholders). Students collected various data from several single interviews, analysed and reflected thereon, before finally delivering their findings to the dean and partner.

BENEFITS, BIAS AND DIFFICULTIES OF THE EVALUATION MODEL AND PROCESS APPLIED

Distance and Partiality

Having the CDIO evaluation run by students has pros and cons. The fact that students are outside of the Telecom Bretagne operational point of view could be seen to serve as a more impartial CDIO rating. It could also encourage positive comments from interviewees instead of complaints. Educational frameworks, either defined and proposed internally, or defined externally, such as the CDIO or national or international QA rules, are sometimes subject to resistance to change from stakeholders. This student-led evaluation has permitted to spreading some CDIO messages, via the student voice, to the interviewees and the student network. However sometimes unexpectedly, the students tended to conduct self-interviews and thus lacked distance and objectivity, answering some questions themselves.

Apart from the model, students also had to deal, in the proofs, with lack of coherence between interviewees, with false or erroneous positives or negatives (some saying that, others saying the opposite or tending to opt for as yet non-effective or fully deployed practices). As a perspective, before analyzing each standard, each CDIO formal expression should be more clearly documented, e.g. "*What are evaluation groups, stakeholders, program leaders, engineering workspaces, integrated learning experiences within the program? How are they implemented?* ".

Semantics, Diagnosis, and Interpretation

All the input CDIO documentation used by the team is written in English and no official French translation is available. As such, the discussions with interviewees tend sometimes to be unclear and subject to ambiguities. The language barrier is finally a serious matter and it critically slows down comprehension by non-fluent English speaking stakeholders. In educational sciences, French and English terminologies, even models, tend sometimes not be coherent. Semantics

vary. A process-based evaluation method could be a first solution for this matter, as it would require less language comprehension and minimize erroneous interpretations. Another solution that has been used in some non-English speaking countries such as Sweden, Finland, Russia and China is to formally translate the key documents into the local language.

When interpreting and adapting the CDIO principles to the Telecom Bretagne program, a need to associate CDIO terms with those of the school environment was clearly identified. However, this association has been made in an informal way. Moreover, from a student perspective, rating each CDIO Standard has proven to be a laborious process because of the difficulty in making exact analogies between Telecom Bretagne and CDIO standards. As an example, let us analyze CDIO Standard 1 (The Context), containing the criteria "CDIO is adopted as the context for the engineering program […]" in scale number 3. One is left with the question of what would be "adopted as the context". The answer can be formulated using maturity levels, such as: adopted by Management, adopted by Management and program leaders, or adopted and understood by the whole educational system and staff. The imprecision comes from the written standard criteria texts. An evaluation group could easily go all the way up to a rate of 5 for the standard by having low maturity level requirements. Additionally, the evaluation group could make the assumption that an "explicit plan" (scale number 2 of CDIO Standard 1) should only be achieved when all program leaders participate in the plan, staying in scale 1. This example emphasizes the importance of detailed documentation of the self-evaluation. The self-evaluation report has to show the understanding behind each evaluation with evidence, rationale and plans to improve.

Apart from the ratings, CDIO standards 9 and 10 were found the most difficult to evaluate by the students.

Time Constraints, Evaluation Planning, and Completeness

The Program evaluation was a work package of this specific S4 project, which means that the time allocated to it was limited. The initial time scheduled in the Gantt chart for the evaluation was 200 hours but more time was finally necessary. It was also very difficult to plan the interviews due to the different constraints of students (one day per week dedicated to the project) and teachers, faculty or program leaders. Also, finding common availability to interview people is a challenge when being a student without the formal support of management, which confirms time constraint problems and limits the amount of stakeholder feedback. As such, time constraints did not allow full coverage of stakeholders (e.g., the human resources manager or alumni were not interviewed). Despite the resource limitations the project group delivered all the planned documents on time to the client.

As for the interview guide, it was naturally developed at an early comprehension stage of the global context, which did not help optimal gathering of all the information needed to rate the standards. As the project team experience evolved, several modifications were made to the interview guide to optimize results. Therefore, some stakeholders have had to be interviewed several times to gather missing information or refine unclear data.

STUDENT SKILLS FOR QUALITY ASSURANCE IN HIGHER EDUCATION

In addition to general skills developed in S4 projects, students developed specific skills linked to Quality Assurance that are: 2.1.3 Estimation and Qualitative Analysis, 2.1.4 Analysis with Uncertainty, 2.1.5 Solution and Recommendation, 2.4.2 Critical Thinking, and 3.2.7 Auditor Communication Skills. As regards communicating with the client partner, all project reports and documentation used were in English and, as such, the students improved their competencies in

oral and written English communication (3.3.1). The quality of written English project documentation was good and the teleconferences with the client were organized, well prepared and competently carried out.

However, due to a lack of knowledge in education engineering and quality assurance, as a feedback, more time for preparation is recommended for such projects, if the twelve CDIO standards are to be addressed. To conduct an efficient and more precise audit, a full-time student team should be involved. Engineering students are not education specialists, and in most cases inexperienced in quality assurance. For better efficiency and precision, an educational expert should be present in the evaluation team, from time to time. Supervisors in this project were not always available during student meetings, or for all the interviews. Unfortunately, for a first experience, time dedicated in the first phases of this project was not sufficient to thoroughly master the CDIO standards and the institution framework before conducting the interviews. More time for more interviews is also needed in the case of a non collaborative process, if we want to cover more faculty sectors and other stakeholders (e.g. alumni, students, industrial partners). Students should take care not to forget to give feedback on the evaluation results to the interviewees, as was not properly addressed in this project.

CONCLUSION

The student-led evaluation presented in this paper is in accordance with the continuous internal improvement loop based on CDIO standard 12 and pinpoints original weaknesses. Supported by students as key actors in the change process, the rating results are, however, to be taken with care and to be compared with other evaluation processes and results (scores on the CDIO standards were respectively: 1 for Standards 1, 10 and 12; 3 for Standards 2, 4, 5, 6, 7, 8, 9, and 11; 5 for Standard 3). The main limitations to enforcing the results were time (200 hours spent) and student initial knowledge of educational frameworks. As a conclusion, thanks to this semester-long experience with sophomore students, the evaluation should be broken into two phases: a first phase for comprehension and a second for evaluations, perhaps with several simultaneous projects to focus on specific standards or stakeholders.

The 12 CDIO ratings (radar) proposed by the students were not exactly the same as those elaborated by the proxy of the dean of academic affairs for CDIO Project Implementation, which were higher on some standards. In fact, none of these stakeholders can support a fully objective evaluation. The causes are both the various biases in each phase and the evaluation model. However, ultimately, is it so necessary to compare radars? The more stakeholders there are, the more the continuous improvements principles can be spread and shared in practice. As non normative, the CDIO evaluation model is sometimes informal and subject to confusion, but it is also a strength in terms of usability. Some communities consider that evaluations are to be repeatable, as SPICE-ISO 15504 standard for System and Software processes evaluation [15]. In another work package of this project, students worked on improving the methodology and CDIO evaluation model by studying the SPICE assessment model to aim for more precision and objectivity. The proposal made by the student team is interesting and may provide new ideas to improve the CDIO self-evaluation model and its rubrics.

From the viewpoint of the external client, the S4-project was a successful experiment. It reached the goals set at the beginning of the project. It was able to provide interesting results and it increased the client's understanding of French higher education and the education provided at Telecom Bretagne. As a perspective, student-led evaluations can be fruitfully conducted by groups external to the program, but belonging to a similar type of institution. Such a model and

process of cross-evaluation or cross sparring could be beneficial for both the institution evaluated, which will get a more objective view of its strengths and weaknesses, and for the evaluation team which may identify best practices that can be useful for its own institution. Perhaps it could bring opportunities for collaborative projects between CDIO institutions or a specific CDIO Academy.

Acknowledgments

The authors wish to thank the students involved in the presented project, namely, Xu Chen, David Dias, Amine Elbelghithi, Benjamin Kojchen, and Bing Xue. Their colleagues, Myriam Legoff and Eamonn Ryall (who reviewed also this paper), are also warmly thanked for their participation in student tutoring. Benjamin Kojchen is especially acknowledged for his availability and comments, both of which contributed to his presentation of the first results of this project to the international CDIO Fall meeting at Telecom Bretagne in October 2012 (http://conferences.telecom-bretagne.eu/cdiofallmeeting2012/).

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BIOGRAPHICAL INFORMATION

Dr. Claire Lassudrie is a researcher in the area of software process assessment and improvement and risk management. She has worked as an Associate Professor at Telecom Bretagne since 2003. Before that, she worked for 20 years at the France Telecom Research and Development Center, where she was involved in a major process improvement program based upon ISO SPICE. She is a competent SPICE assessor and contributes to ISO and French AFNOR standardization groups on System and Software Engineering. Mrs Lassudrie has run many courses at Masters level in the area of quality, process improvement and software engineering, both for engineering students and vocational students. She is also an active member of the Telecom Bretagne quality assurance group.

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Dr. Siegfried Rouvrais is currently Associate Professor at Telecom Bretagne. He organized the international CDIO 2012 Fall meeting. For the last ten years he has been particularly involved in educational program design, with a focus on experiential learning and student competency development. Author of several international publications in Engineering Education, his current scholarly interests are in certification, accreditation, and continuous improvement models and processes for HEI reforms. Dr. Rouvrais received his Ph.D. in Computer Science from the INRIA Lab. and University of Rennes, France, in 2002.

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